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APPLIED ENTOMOLOGICAL TAXONOMY*

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Governmental, that is tax-supported, institutions are assuming increasing responsibilities for the welfare of the general public. Tax-supported economic entomology is no exception to this, and governmental organizations are the principal places where economic entomologists find employment. When tax money is spent for arthropod taxonomy in connection with economic organizations, that taxonomy must be the kind that can be directly applied to pest control, because pest control is the chief entomological interest of the tax payer. Thus, most tax-supported taxonomists work with arthropods as they relate to legislative pest control, surveys, insect eradication, chemical control, and biological control. He must furnish identifications of species, and bionomical and distributional data. I have been engaged in this type of work for the past fifteen years, and this has given me a considerable opportunity to gain experience with, and to observe, what sort of taxonomic work is required, how adequate the existing taxonomic literature is, how specialists in this subject meet their problems, what attitude these taxonomists take toward their work, and how the institutions that need this work support their taxonomists.

From this experience I have developed the conviction that applied taxonomy can have more definite objectives than it now seems to show, with resulting benefits to economic entomology. But the responsibility and vision for maintaining such objectives must rest largely in the organizations hiring taxonomists.

We may define applied taxonomy as that portion of arthropod classification dealing with the specific identification in and the bionomical coordination of, anthropod groups containing species in competition with or dangerous to the human animal; or in groups which contain species that help control effectively the

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harmful kinds. In other words, this form of taxonomy is a restricted activity. Arthropod groups having the greatest number of important species receive the most attention, with those having fewer important species receiving proportionately less.

Taxonomy in its broadest and most fundamental aspect is principally the search for facts bearing on the origin of, and interrelationships and differences between, organisms and groups of organisms. Any restriction of taxonomy such as that here treated, must rest on the fundamentals.

Our gauge, as to the direction in which the energies of applied taxonomy are expended, rests on evaluating each group of arthropods according to the number of economic species it contains. I use the word *group* because taxonomy is a science of comparison, and the taxonomist knows important species thoroughly only after he has carefully compared them with all similar species. Thus, a group may be anything from a portion of an order to part of a family. For example, a worker who compares and describes species in the scale insect group, continually sharpens his wits on identifying a considerable number of economic species. Opposed to this, a person studying dragonflies could not, by that activity, identify any economic species. This does not mean that the taxonomy of dragonflies, mayflies, and other groups we might mention, is worthless. Such studies obviously have a definite place in entomology, but are inappropriate when supported by economic organizations.

The most important activity of the applied taxonomist is the identification of species. In taxonomy which seeks the fundamentals of arthropod correlation, the identification of species may well be of secondary significance. But in economic entomology the identification of an important species is the key to the situation. It is the first step of an economic operation. It gives the control man access to the past literature on the pest, and enables the orderly recording of new data. Our most notable recent example of the role of taxonomy in economic operations is the identification of a single caterpillar from Orange County (California) in October, 1942, as the larva of the oriental fruit moth. There followed many meetings of fruit growers and entomologists consuming considerable time and traveling expense. The State Legislature appropriated over $850,000 for various phases of investigation and control. Between 500,000 and 600,000 moth specimens that were caught in the oriental fruit moth traps were identified in order to segregate the actual oriental fruit moths and learn the range of that species in California. While the moth was discovered here too late to allow eradication, taxonomy has opened the way for control procedures and investigations before the pest has overrun commercal fruit orchards.

With the principal activity of applied taxonomy in mind, namely the dispensing of specific determinations, it follows that the next most important thing is that of seeking new and better methods for differentating species, and for the recording of new species—a large task. Increased knowledge on species differentiation has in recent years had a profound effect on the control of screw-worm flies, red, yellow, and related scales, tomato pinworm, and others. As little planning was done looking toward such results, we can only wonder how many more such things remain to be discovered by the chance of personal initiative.

The application of taxonomy to economic entomology has been, and is being, practiced in a very limited fashion. Not many tax-supported entomological organizations give it a definite place in their set-ups. It enters into the planning of almost no economic projects. Commercial insecticide organizations freely consult governmental taxonomists but assume no responsibility themselves for the development of knowledge on insect identification. Applied taxonomy is not taught anywhere as such. Aside from what research the man on the job can do himself, the most he usually obtains from outside sources is an occasional chance article which is partly useful.

The main reason our systematic data so often fails the applied taxonomist is that he must examine material and use techniques not popular with the usual taxonomist. This material consists mainly of species in the order Homoptera and of holometabolous larvae. While the source material in the Homoptera is in most respects fragmentary or preliminary from the applied viewpoint, one family of scale insects, the Diaspididae, has recently been well clarified. Let me point out that scales have perhaps more economic species than any other group of comparable size, and that the worker who has thus helped us is not employed by an economic organization.

It is in the research on and knowledge of immature forms that we find the most discrepancies in data available to the applied taxonomist. We have some valuable leads toward identifying holometabolous larvae but most of them are barely introductory. Keys for identification of caterpillars by Fracker, for coleoptera larvae by Böving and Carighead, and for part of the more primitive maggots by Malloch, are among the best examples of comprehensive literature on holometabolous larvae. In many particulars the identification features of important immature stages are at best in the minds of but a few people. The medical side of applied taxonomy is probably in the best position, with considerable thoroughly-developed literature, especally on mosquitoes and their larvae. In contrast to this, in spite of all the years that the cotton boll weevil and relatives have been serious pests, we still have no careful analysis of the larvae of species in the anthonomine group. We know very little about immature Homoptera and Hemiptera. Immature stages, especally holometabolous larvae, are usually the ones found doing the damage, and their identification is the key to the situation, as pointed out in connection with the oriental fruit moth. This is vital to economic entomology, but there is no clearly-defined effort to do anything about it.

Research on new and better methods of species differentiation includes other activities as well as critical laboratory analytical methods. The collection and study of arthropods in the field by the taxonomist not only enables him to get adequate material, but gives him invaluable perspective on his work. This is true in regard to quarantined insects that do not occur in the area in which the applied taxonomist works, but the identification of which gives a meaning to legislative control. And, in order for the taxonomist to correlate the visble structures he studies with the habits or activity of the species, and to disclose the true nature of polymorphism, applied taxonomic studies should be conducted in connection with greenhouses and rearing rooms.

If we stopped our consideration of applied taxonomy right here, this branch of classification would be abundantly worthwhile. But there is more to it than that. The simplest way taxonomy aids insect control beyond species identification is by enabling the economic entomologist to borrow methods from the control of species similar to the one under suppression. An example would be the use of established scale control methods on new scale pests. Thus, taxonomy serves as an orderly basis for thinking, and correlates control methods. The spectacle of an economic entomologist fastening his attention entirely on one species gives the impression that he will sooner or later be operating with a poverty of new entomological ideas. The codling moth control fraternity is perhaps the best example in this case.

Another way taxonomy can go farther than species naming is that of defining genera whenever possible, so that they not only have a structural significance, but also a bionomical or geographical aspect. Geographical considerations are of prime importance in parasite explorations. In this connection, biological control organizations seem to have neglected what we might term the "geo-taxonomy" of the insect groups that contain species they seek to control.

Taxonomy is primarily based on the comparison of arthropod structures. These structures are present because of some mechanical value to the individual arthropod. Structures are visible mechanisms, and the taxonomist, by comparing them, makes logical arrangements of these visible mechanisms. Important control methods are based on such things as oral mechanisms, skin structures, and gland secretions. These have definite places in taxonomy, which has a wealth of comparative data on such structures. It is of profound significance that serological studies indicate that the chemical similarities of arthropods closely follow their mechanical affinities.

Since taxonomy proceeds largely by the process of thorough comparison, therefore comparison is at the basis of taxonomic reasoning. With this fact in mind, let us momentarily analyze present practices in arthropod-control research. We immediately see a strong tendency to treat arthropod pest species as unrelated entities. For example, there are many articles in existence describing the reactions of one species of insect to numerous control chemicals. That is perfectly correct as far as it goes, but taxonomic reasoning indicates that if the reverse aspect of this is not also investigated the whole thing is lop-sided. In other words, the reactions of numerous arthropod species to single chemicals will give interspecific variations in reaction, and these variations can then be correlated with visible mechanisms and biochemistry. This does not imply that such a thing ought to be done in connection with each control project, but as a standard practice to give valuable data to control projects. The significance of the reciprocal toxicity of sulfur and cyanide to arthropods lacking or possessing spiracles would be a good subject for an investigation of this type. The chemical side of the problem is the "what" side; the arthropod side the "why" side. I am not referring in this case to attempts by insecticide companies to sell their products as cure-alls.

Remarks have already been made leading up to the statement that applied taxonomy needs some special literature. There is no better origin for such literature than with the applied taxonomists themselves who owe it to their profession to publish the identification problems they solve. The type of literature needed is not that which is illustrated by a photograph or general sketch, but by figures drawn on the basis of interspecific and intergeneric comparison, analyzing the body comprehensively. There is enough information in existence scattered through books and periodicals, preserved in collections, and in the minds of a few people, to form a valuable manual or manuals, on preparatory methods and characters for the identification of economic arthropods and near relatives. With this as a basis we could build further knowledge in a really effective form.

Let me conclude by repeating that the application of arthropod taxonomy to economic operations means restriction to study of pertinent arthropod groups. This taxonomy, as well as being restricted, has certain definite procedures and objectives, the most important objective being species identification. Applied taxonomy depends for its future development squarely on the intelligent support of the organizations that need it. While the economic value of taxonomy is conceded, there is a general passive policy, both expressed and implied, that the solution of pertinent taxonomic problems must be largely based on the chance coincidence of opportunity and ability or inclination. Amateur taxonomists have done important work, but economic entomology is a large and growing profession, and the amateur or passive slant on applied taxonomic development cannot assure such progress as is needed. Economic entomological organizations will find that the only effective applied taxonomy is that for which they are willing to be actively responsible.